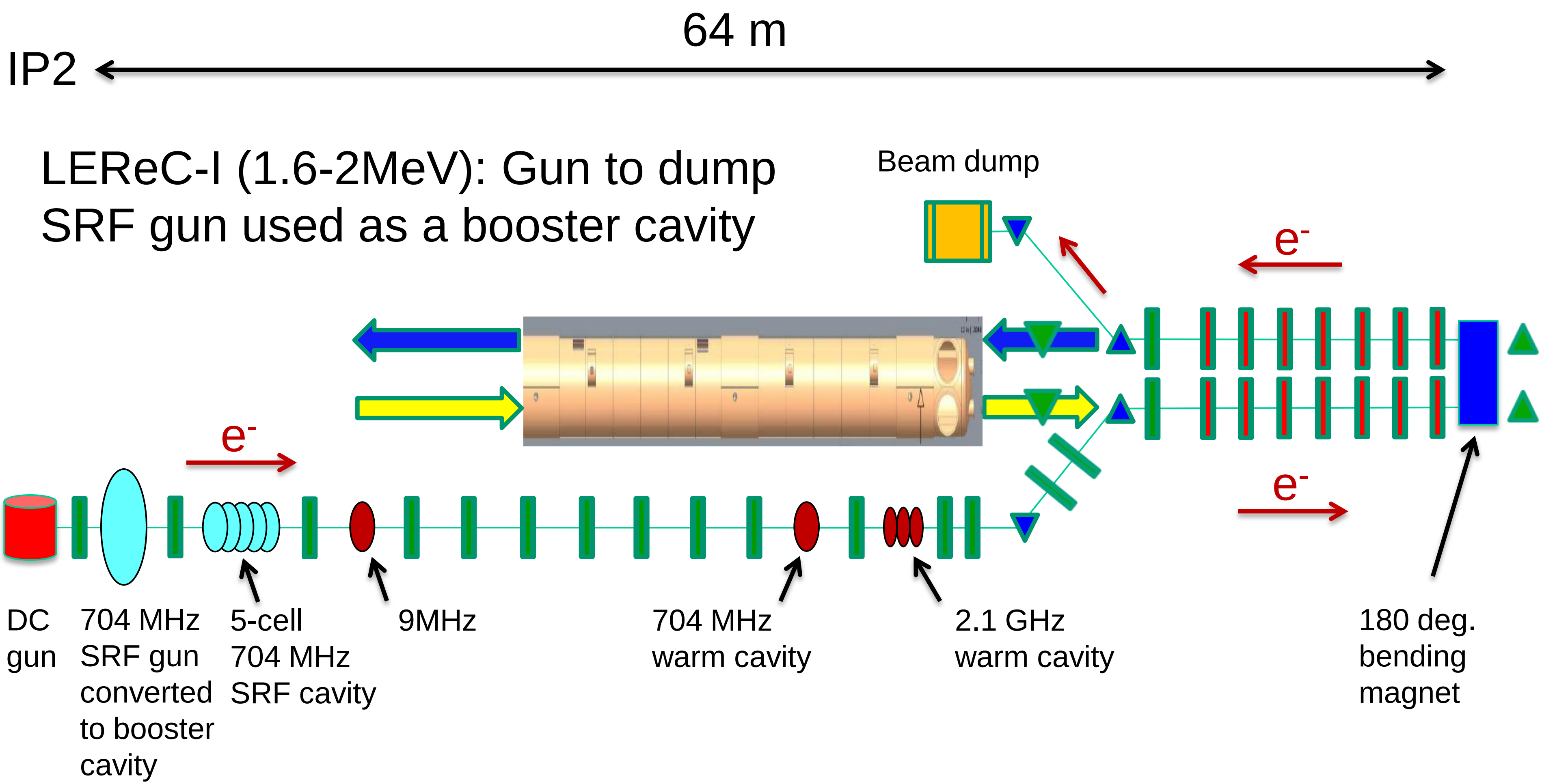
LEReC-I (1.6-2MeV): Gun to dump
SRF gun used as a booster cavity



Cable requirements for new tunnel penetrations.

20 & 180º Dipole

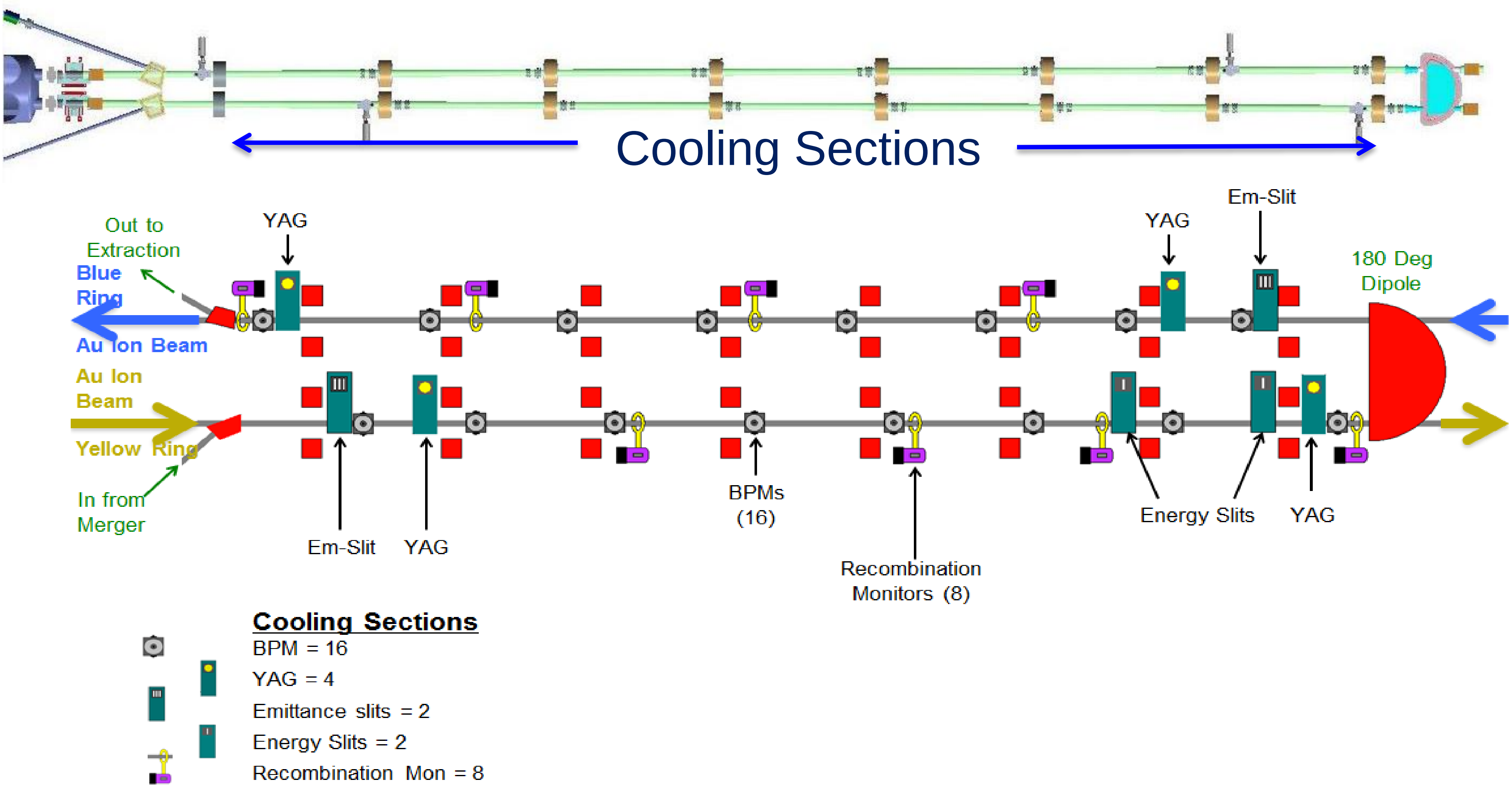
- Concerning energy & energy spread measurements, Mike B. suggested that if the total momentum aperture for RHIC is larger than 10^-3, then a field measurement of the 180 dipole of 10^-3 accuracy would be sufficient. Wolfram confirmed that since the Au+78 ions are not lost, then this should be true. Thus, we will move forward with a field measurement of 10^-3 accuracy for the energy spread measurements using a NMR probe + Hall probe, potentially from Caylar, France.
- According to Jorg's simulations, energy spread in merger using 20 deg dipole should have a horizontal dispersion of 2 – 3 X beam size for the expected 10^-4 energy spread. Thus, we can use the same type of slits as in the cooling section.
- Peter T. made a presentation on the advantages of building the dipole used for energy measurements from laminated steel and employing a degaussing technique (anhysteretic conditioning) to put the remnant field on the anhysteric curve. This requirement would affect both the 180 deg dipole as well as the one 20 deg dipole used in the energy spread measurement.

Vacuum (Transport Line)

- Beam transport line pipe size shall change from 2.5 to that which matches the ERL beam pipe.

Cooling Sections

Magnet Lattice Physics Review
Beam Instrumentation Meetings on Thursday 3:00 PM



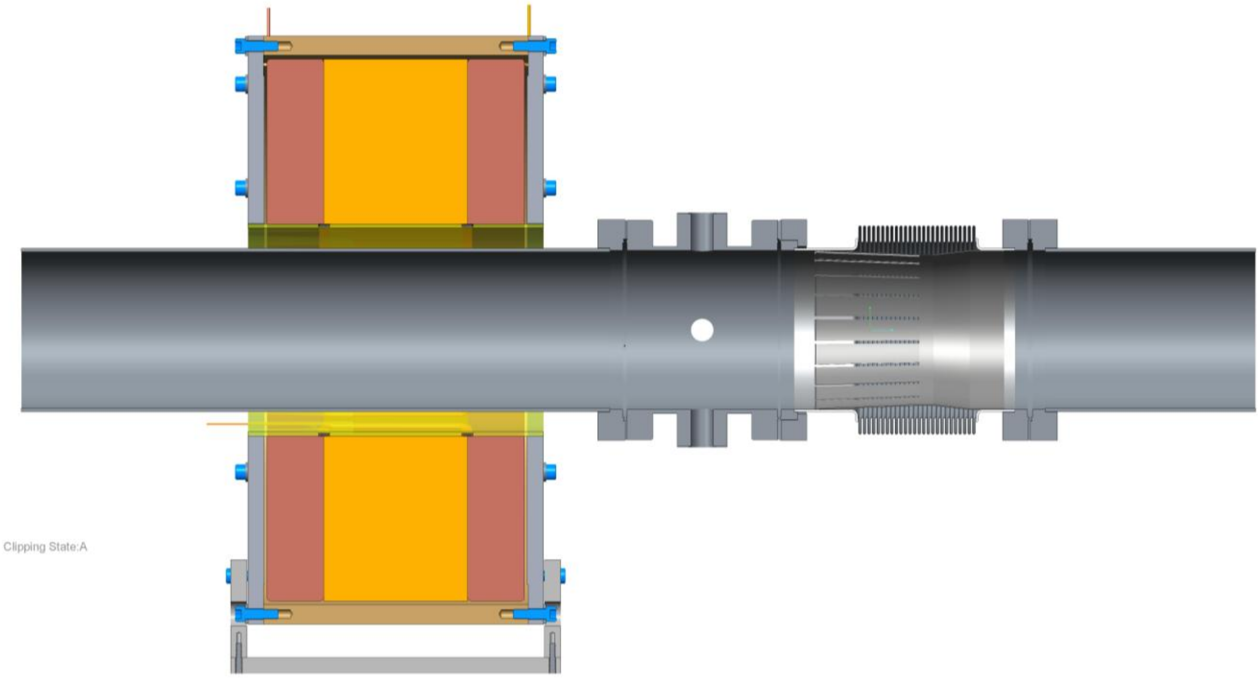
Compensating Solenoids

Bids received. Awaiting best and final 9/15/2015 delivery

Matching Solenoids. Awaiting best and final 9/15/2015 delivery

Design Review:

- Field measurements and positioning accuracy specifications.
- Magnetic shielding measurements
- Magnet measurement fixture Plan for mu metal prototype and test fixture.



20º Dipole Magnet

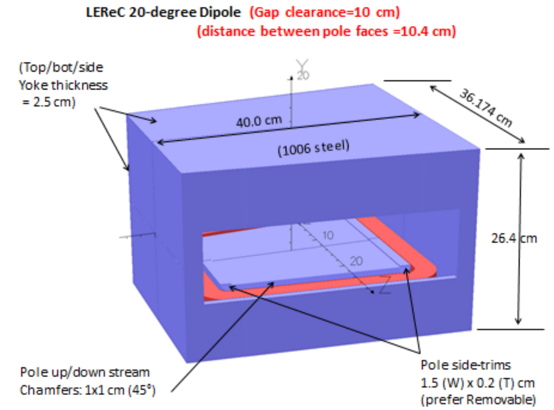
Drawings checked – preparing requisition.

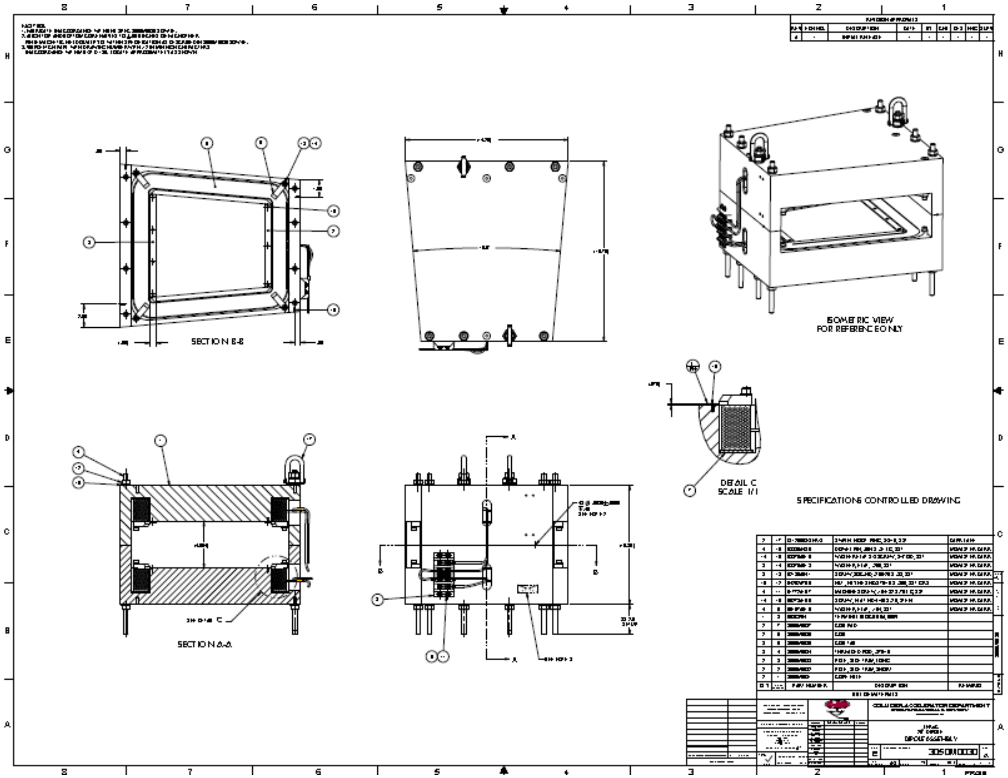
Magnetic field quality and repeatability for energy spread measurement – only 20º

Distance Between Pole Faces = 10.4 cm (4.1 in.)

Magnet Vertical Gap = 10 cm

Vacuum Chamber V Aperture = 9.5 cm (3.74 in.)





Electron tracking results and field qualities along trajectory on R=1 cm curved cylinder:

	Ek = 5 MeV	Ek = 1.6 MeV
Current per coil (Amp-turn)	1053.288	393.192
Overall current density (A/mm²) (overall coil cross-section 3.0x4.8 cm)	0.73145	0.27305
Central Gap Field (Gauss)	251.20	93.73
Half b1-integral (dipole) (G-cm)	3.1982E3	1.1930E3
Half b3-integral (6-pole) (G-cm) [Ratio to dipole integral]	1.803E-2 [5.64E-6]	7.019E-3 [5.88E-6]
Half bending angle from tracking tests (required 10°)	10.013°	10.006°

180º Dipole Magnet

Magnetic field quality and repeatability for energy spread measurement

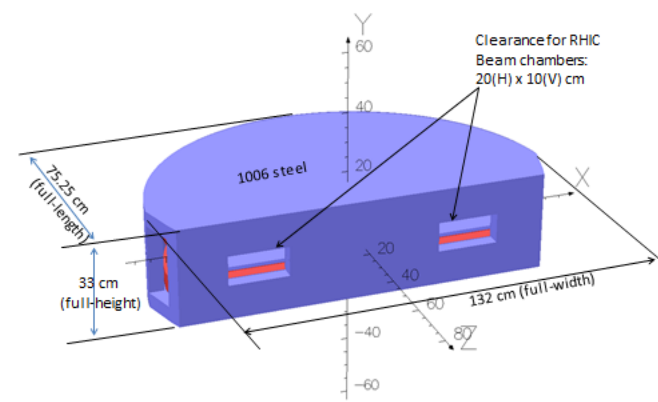
Range of motion for magnet core +/- 10cm.

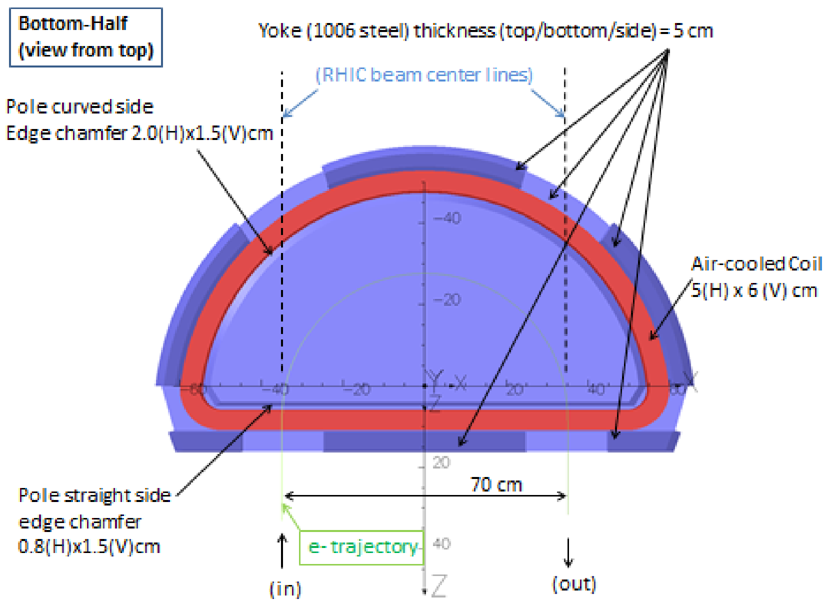
Core field quality: Test using CeC dipole (A. Jain)

Magnet Vertical Gap = 10.0 cm (3.94 in.)

Vacuum Chamber Aperture = 9.5 cm (3.74 in.)

Use CeC 45º dipole for low field measurements

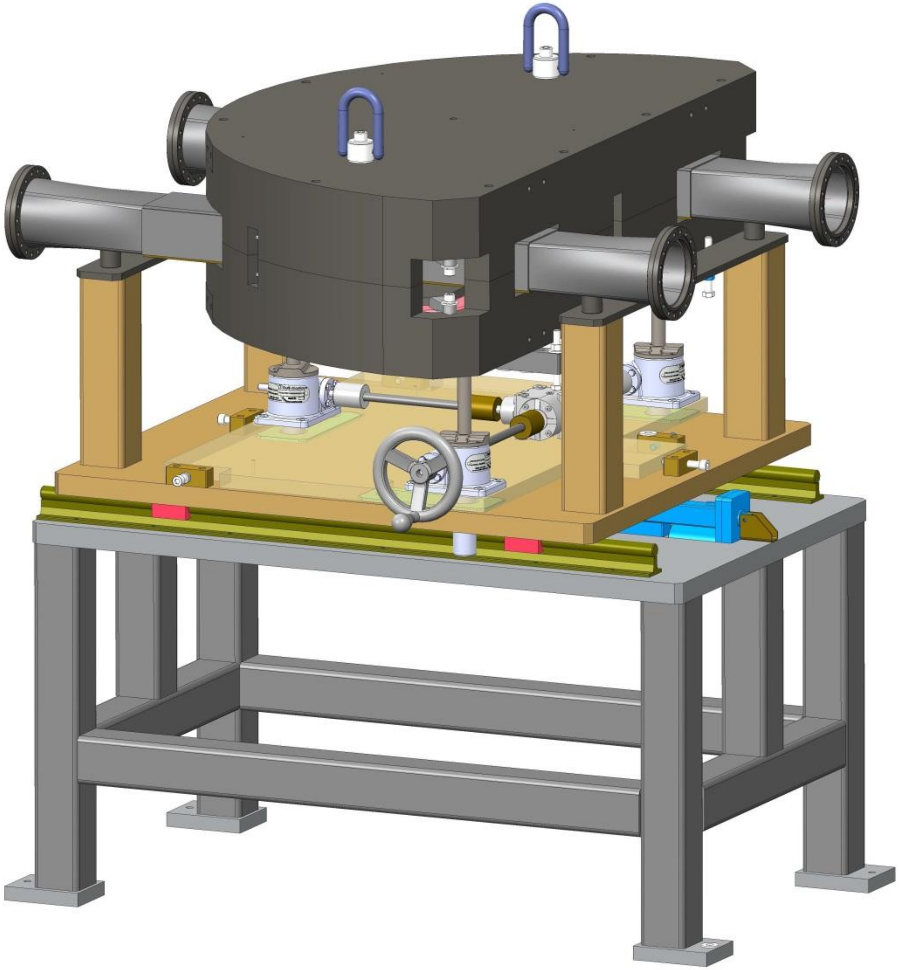


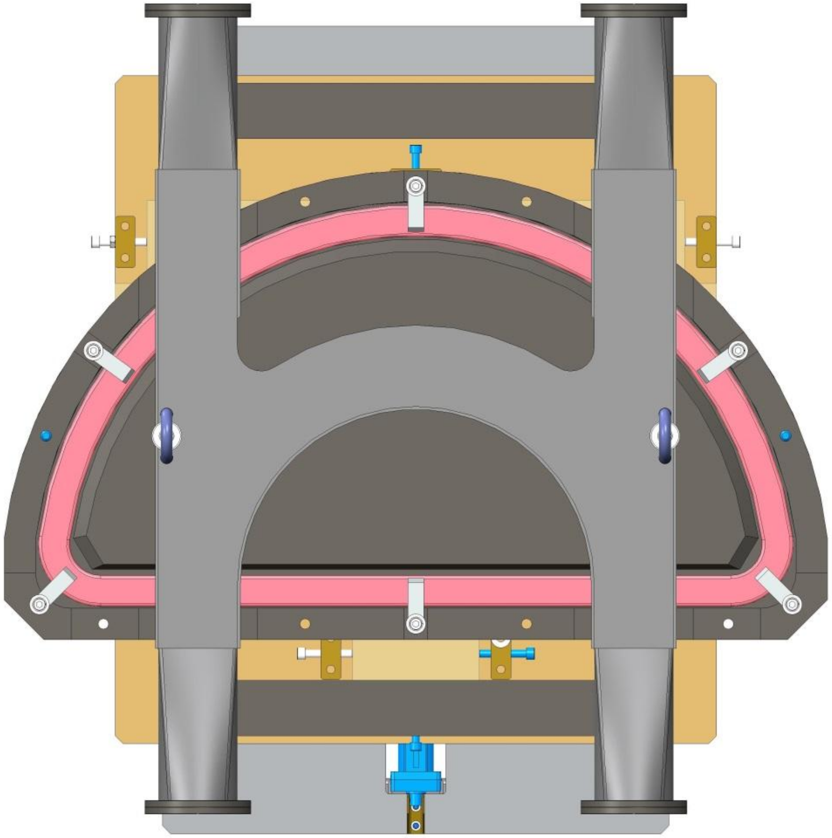


Electron tracking results and field qualities along entire trajectory on R=2 cm curved cylinder:

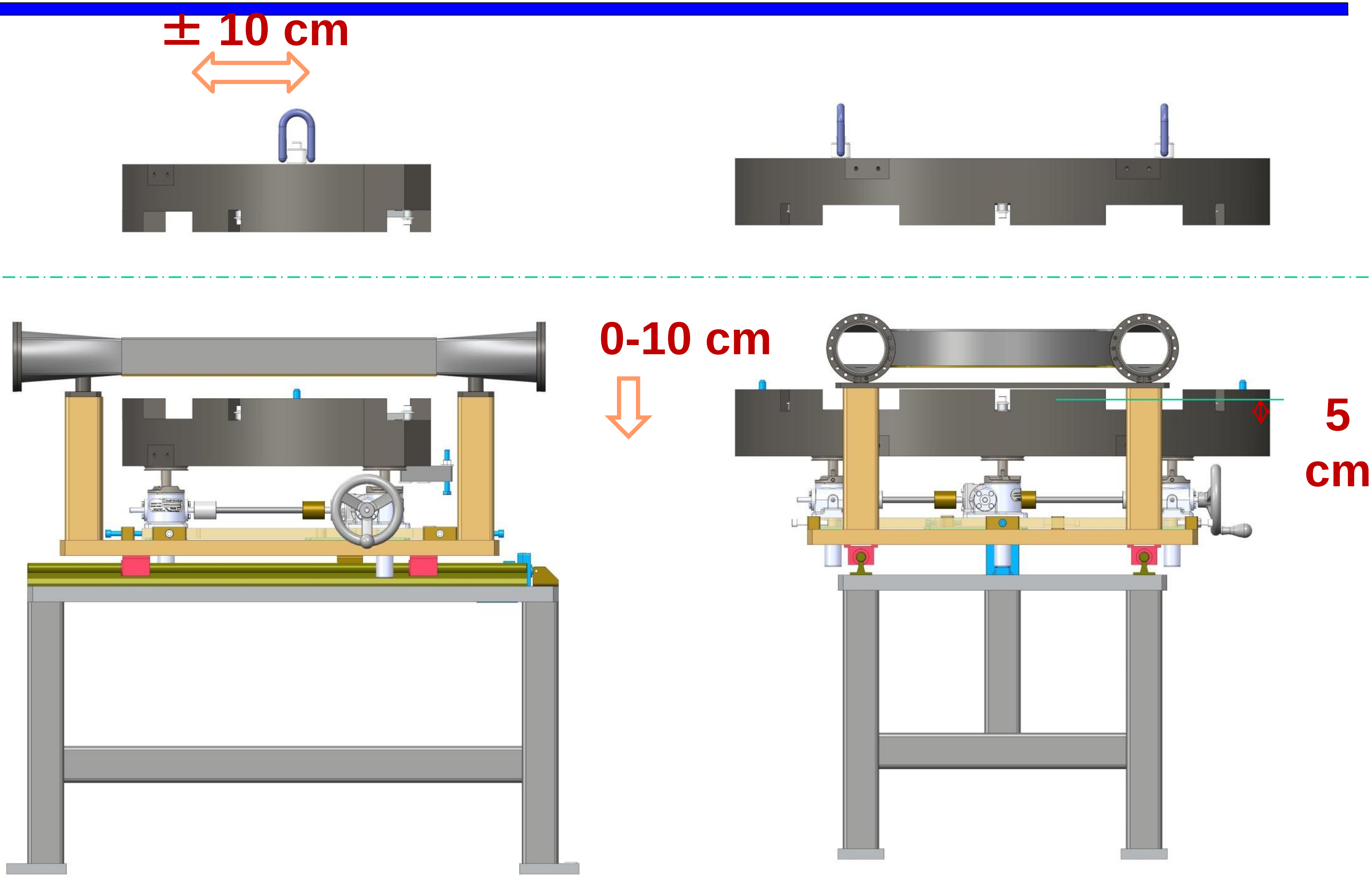
	Ek = 5 MeV	Ek = 1.6 MeV
Total current per coil (Ampere-turn)	2119.146	791.077
Overall current density (A/mm²) (coil-pack cross-section: 5.0 x 6.0 cm)	0.7064	0.2637
Central Field deep inside magnet (Gauss)	525.21	195.78
Effective Magnetic Length (cm)	109.43	109.57
Full b1-integral (dipole) (G-cm)	5.7471E4	2.1452E4
Full b3-integral (6-pole) (G-cm) [Ratio to dipole integral]	0.132 [2.30E-6]	0.005 [2.44E-7]
Full bending angle as shown in tracking studies (required 180°)	180.002°	180.003°

STAND, LEReC 180° DIPOLE





Dipole and vacuum chamber



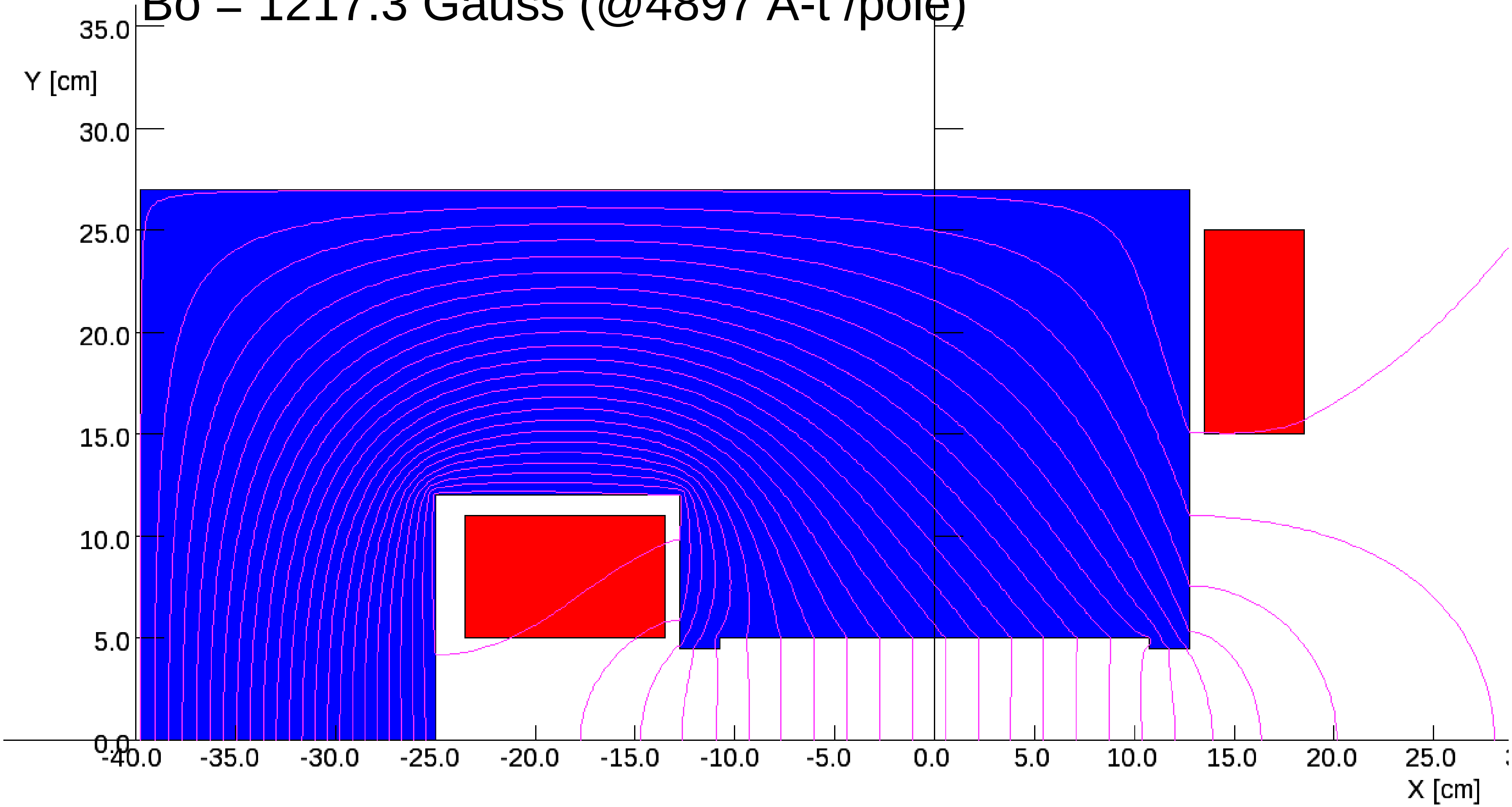
Studies on LEReC magnet materials

W. Meng

24 February 2015

LEP Dipole V.8 --- If use Solid Steel

Bo = 1217.3 Gauss (@4897 A-t /pole)



LEP Dipole V.8 --- PF = 0.27 (Lamination in Opera-2d plane)

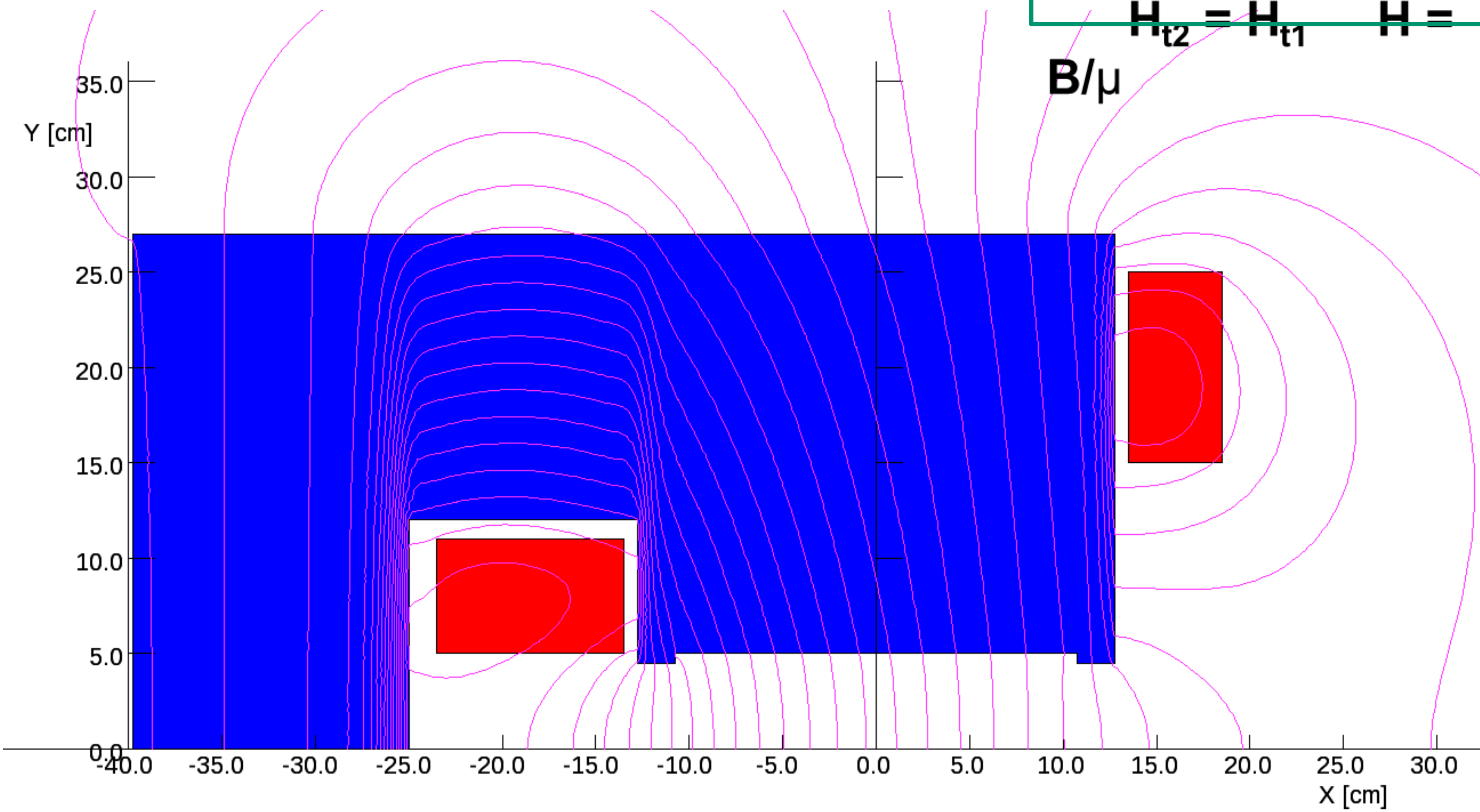
Bo = 310.1 Gauss (@4897 A-t /pole)

Q: Why?

A: (see J. D. Jackson eq. I – 20)

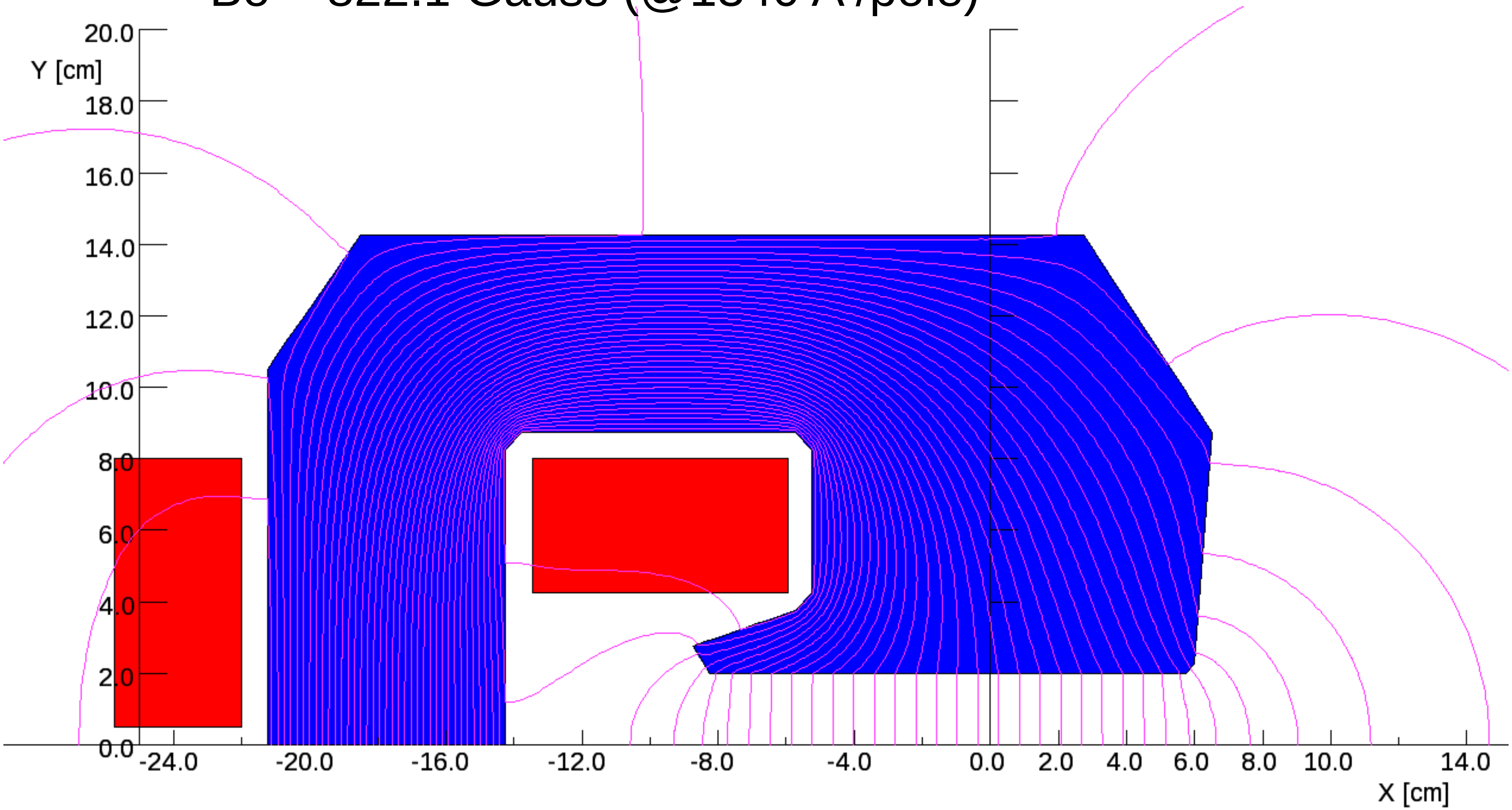
$\mathbf{n} \times (\mathbf{H}_2 - \mathbf{H}_1) = 4\pi \mathbf{K}/c$

$\mathbf{H}_{t2} = \mathbf{H}_{t1}$ $\quad$ $\mathbf{H} = \mathbf{B}/\mu$



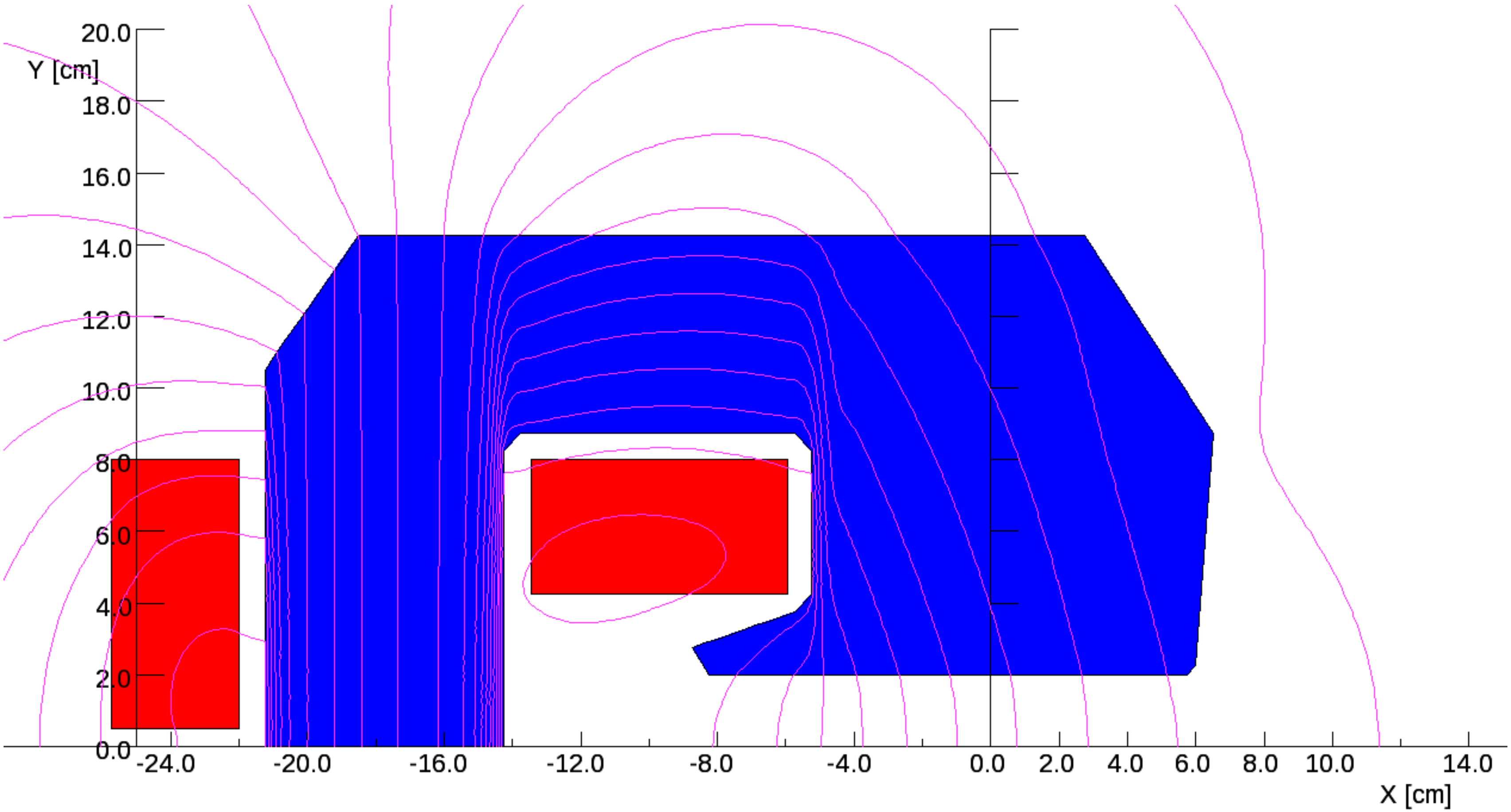
LHeC CERN version (Solid Steel)

Bo = 822.1 Gauss (@1340 A /pole)



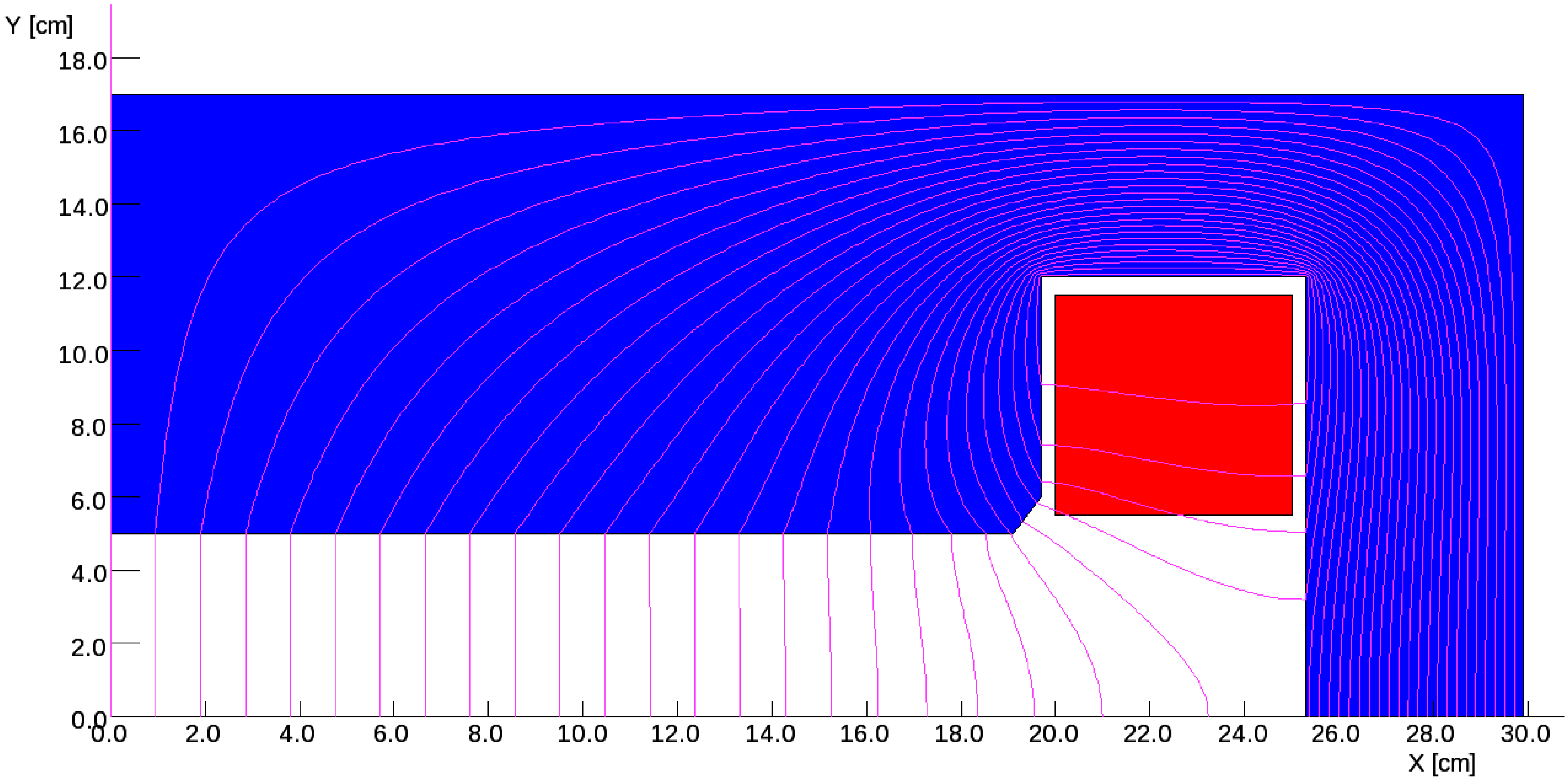
LHeC CERN version (Laminated Steel PF = 0.33, parallel to (

Bo = 113.3 Gauss (@1340 A /pole)



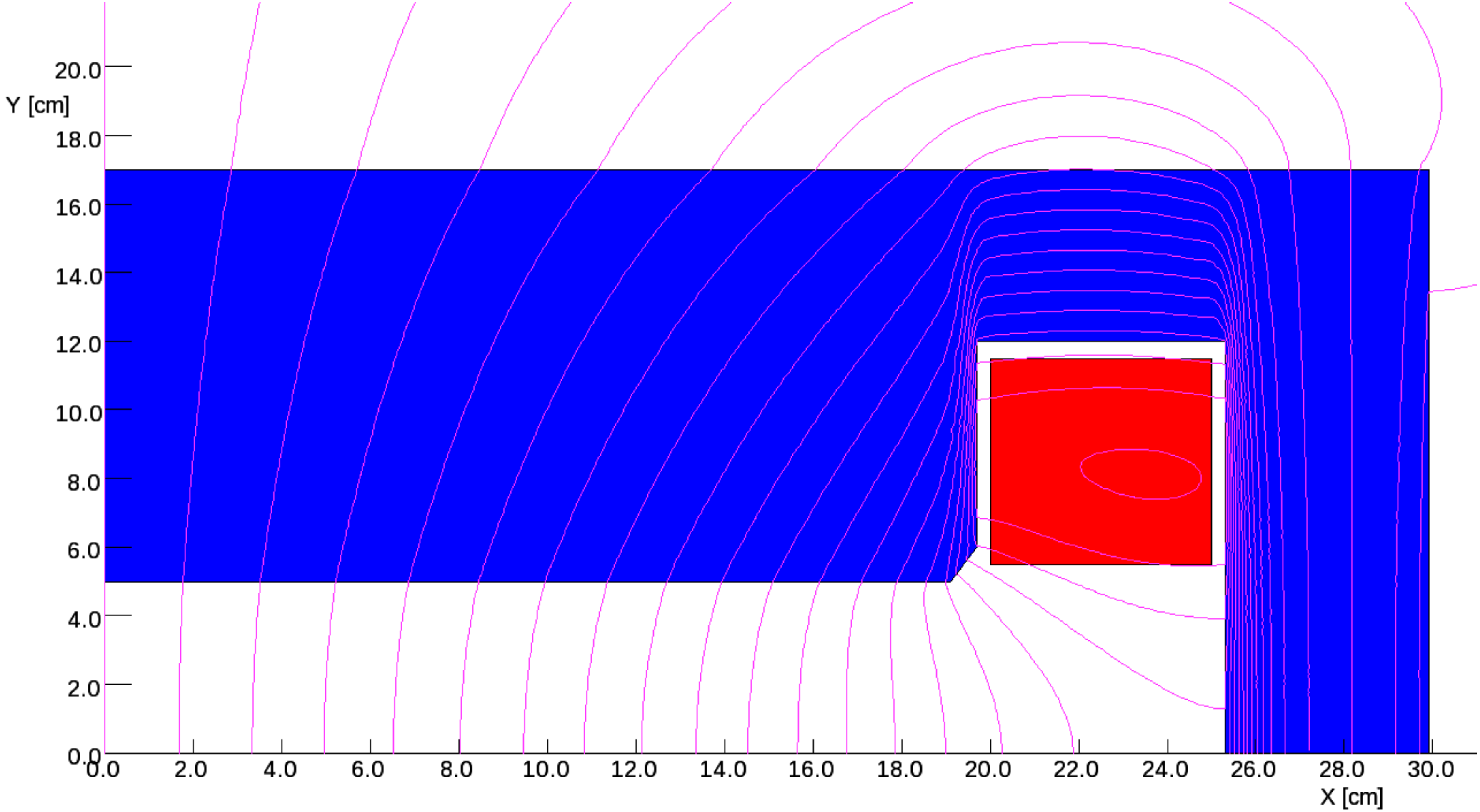
LEReC 180-deg H-type Dipole (simplified) --- Solid steel

Bo = 510.1 Gauss (@ 2119 A-t /pole)



LEReC 180-deg H-type Dipole (simplified) --- Lamination PF = 0.33

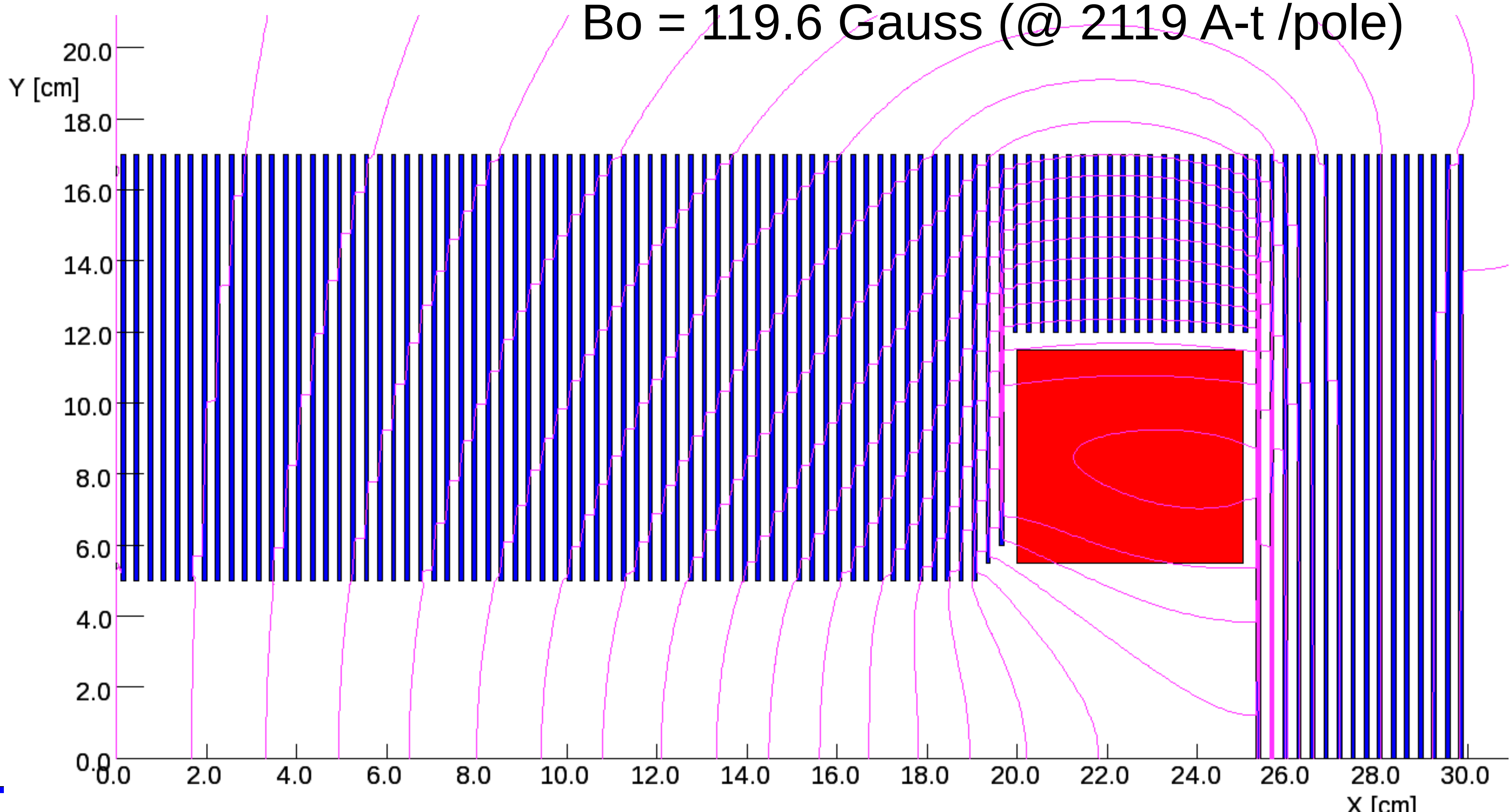
Bo = 119.0 Gauss (@ 2119 A-t /pole)



LEReC 180-deg H-type Dipole (simplified) ---

Multiple 1 mm solid plates spacing 2 mm: equivalent to Lamination in Y-Z plane:

Bo = 119.6 Gauss (@ 2119 A-t /pole)



Low PF laminated material is not a solution for LEReC project ---

(1)We need high field quality (need effectively iron shimming tools)

(2)It will require 4 to 6 times current to get the same fields

(3) It “diluted” magnetic dipoles on the pole-face, but enhanced their strength

(4) Fringe fields may be an issue

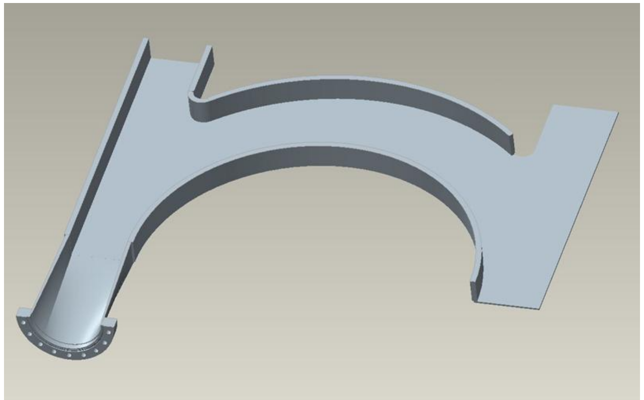
High PF laminated material has the only advantage (demagnetize by using AC Oscillating current with reduced amplitudes). But this is not the only way to de-Gauss.

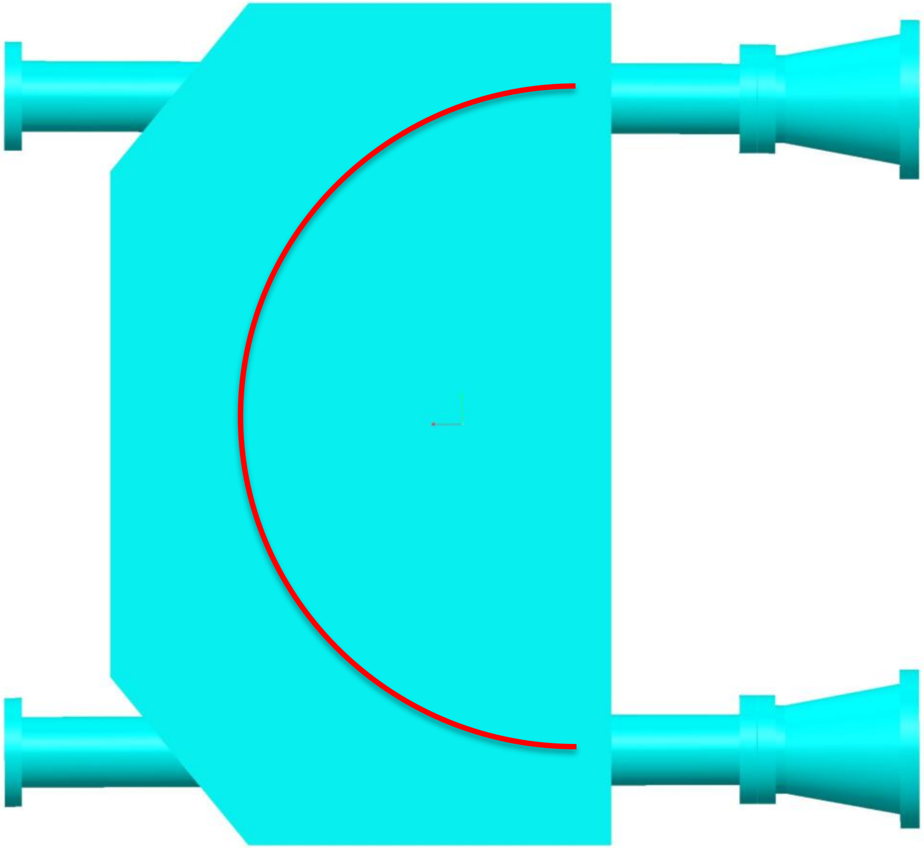
What did LEP do: they “Varied” current “between 300 A and 2900 A several times to restore the magnetic initial condition.” (EPAC-98 TUP04H)

This is the same method suggested by J. Tanabe (Iron-dominated Electromagnets).

Vacuum Hardware

- Large open 180^o vacuum chamber and 20^o chamber - beam impedance concerns shield the electron beam path.
- Design and order beamline RF shielded bellows. Recombination monitors??
- Order RF shielded valves.





Design Room

Beam Instrumentation Profile Monitor Vacuum Chambers (GW)

Beam Line 5” bellows with shields (GW)

20º dipole fabrication drawings, vacuum chamber (KH)

180º dipole magnet and vacuum chamber integration – beam line tuning magnet and vacuum chamber translation (KH)

180º dipole fabrication drawings, vacuum chamber (KH)

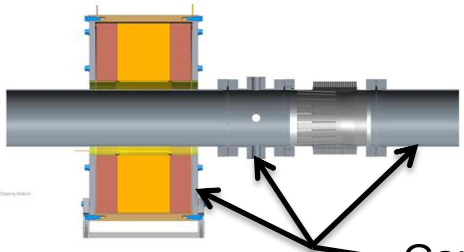
20º and180º Stand drawings (KH)

Beam line solenoid stand (GW) LF Solenoid, BPM, and long pipe are to be independently positioned and surveyed (Note: this can be on common stand).

Beam line Beam Position Monitor drawings? (GW)

Magnetic Shielding drawing and test station (GW)

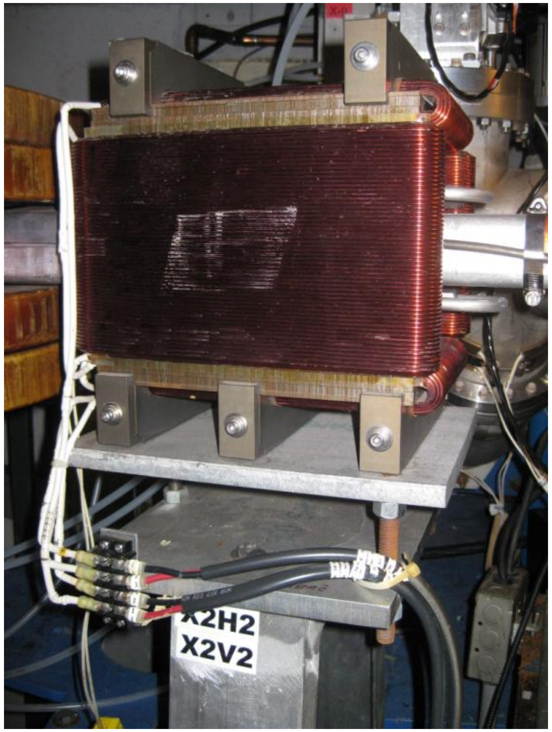
Cable tray and penetration drawings

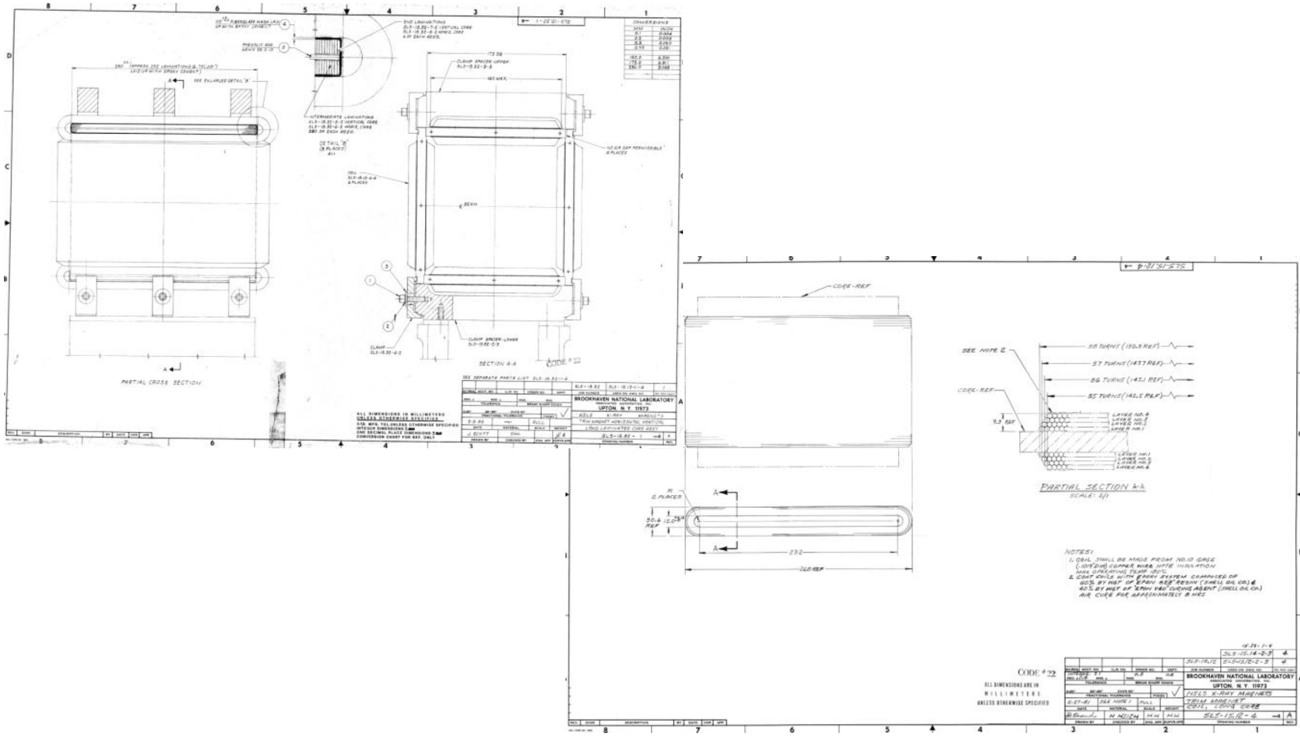


Common support/independent positioning

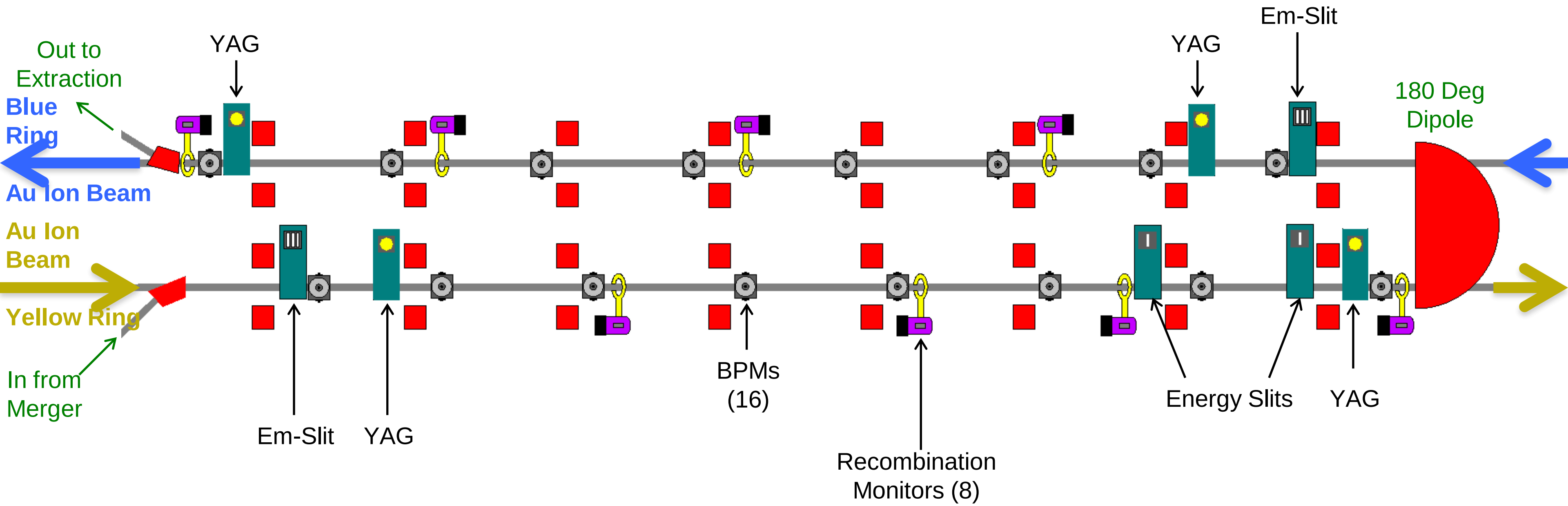
NSLS I Equipment

- Compensating dipole for 21º e beam injection/extraction
- 375 Gcm/A
- On the list





Cooling Section Beam Instrumentation



Cooling Sections

BPM = 16

YAG = 4

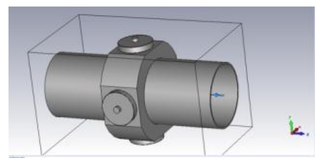
Emittance slits = 2

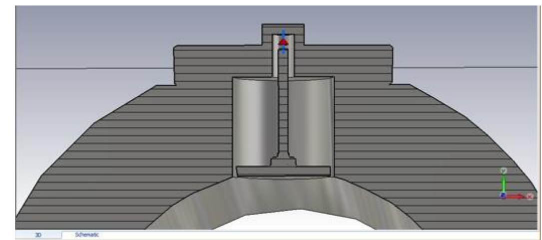
Energy Slits = 2

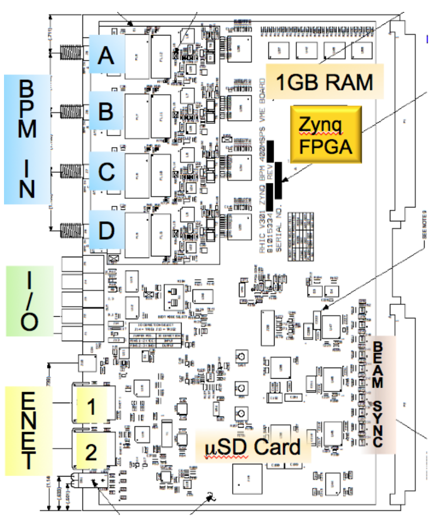
Recombination Mon = 8

BPMs in Cooling Section (14 Locations)

- Large Dia. BPM Housings
- 28mm buttons
- N-Type feedthrough
- MPF Q7031-1



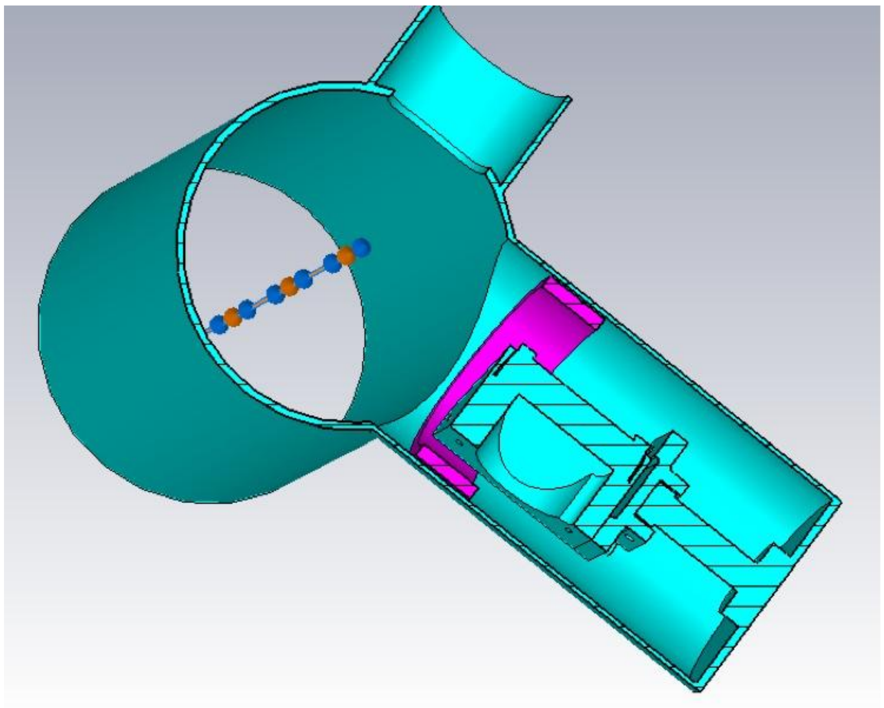


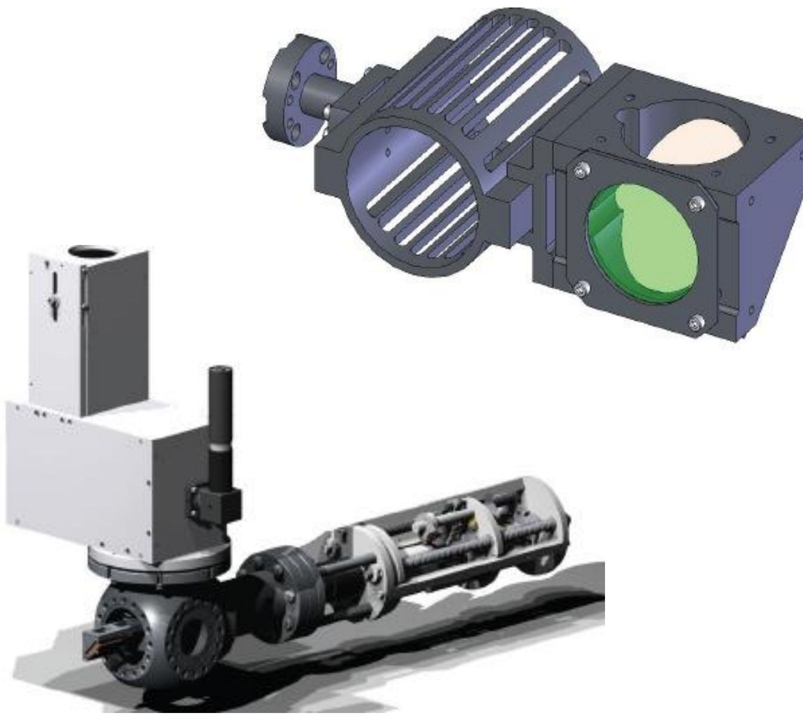


BPM board being ordered for CeC
2 boards for testing in LEReC cooling section

Profile Monitors – New designs for Cooling Section

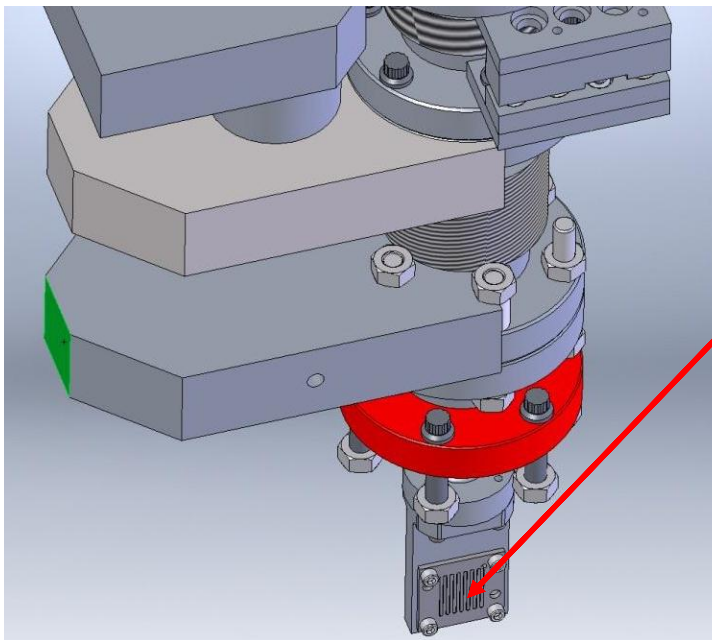
We will need to install a ferrite ring inside the vacuum chamber in the LEReC profile monitors, as shown below in pink.
CMD5005 material.
The cylinder Peter modeled is 1.65” OD, 1.45” ID and 1” high.
This is a sticking point for procurement as it affects the aperture through which the vendor has to insert the YAG holder.

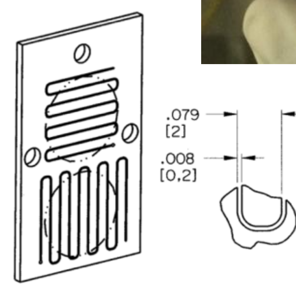




Emittance Slit Measurement

- Low Power Operations Only
- New Dual axis design for Horizontal & Vertical measurements.
- Positioned 0.16 – 1 m upstream of profile monitor
  - Final spacing TBD…
- Tungsten Slit mask, optimized for beam parameters
  - Mask 1.5mm thick… # slits & TBD…





Dual Station Actuator retrofitted for new dual axis mask.

ANALYSIS:
An algorithm was developed for analyzing the image from a multi-slit mask for emittance measurement.

Future plans are to automate the image analysis for on-line processing and data logging.

Intensity Distribution at mask

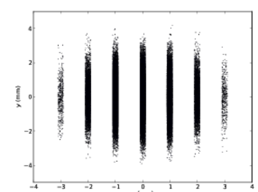
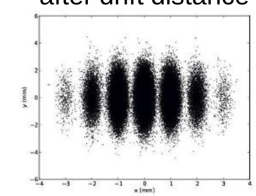
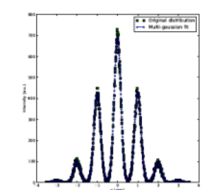


Image on profile monitor after drift distance

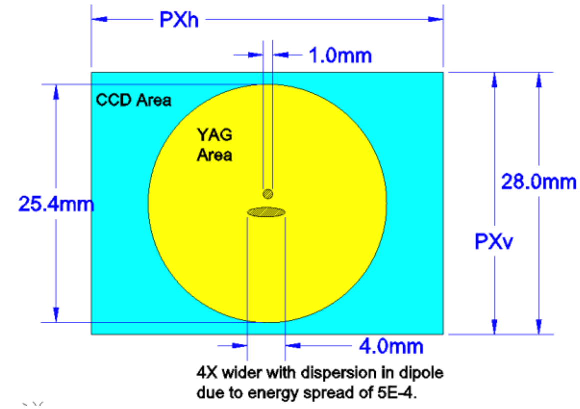




Energy Spread Measurements – 2 Locations

- Max. Energy Spread: $\Delta p/p$ = <5e-4
- Beam Size (d): 1mm (dia.)
- Double Slit before dipole & drift to YAG
- May use **Quad** to increase resolution between cooling sections
- *Considering alternatives:*
  - *Dedicated energy spectrometer beam line*
  - *Cornell's method of using deflecting cavity*

Image of YAG as projected onto CCD



- 2MP CCD: 1292_h X 964_v px
- $\text{Pitch}_{YAG} = \text{proj-H}_{CCD}/\text{px}_v$
  = 29μm/px

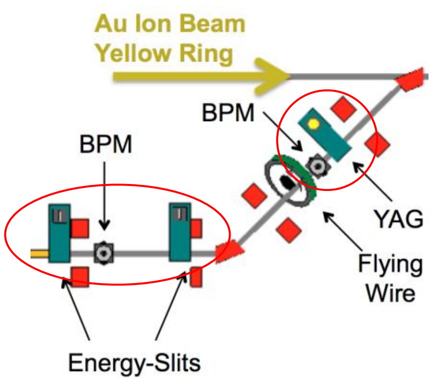
Before Cooling Sections

•σ_δ = 750μm

•Resolution = σ_δ / Pitch_{YAG}

- 750μm / 29μm/px = 25 px

➔ 4% Resolution



$\sigma_\delta = \eta\delta = 1.5m(5x10^{-4}) = 750\mu m$

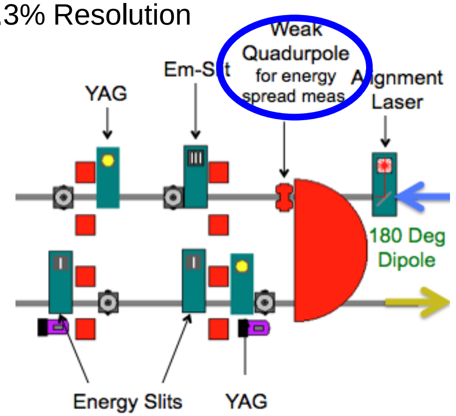
Between Cooling Sections

•σ_δ = 350μm

•Resolution = σ_δ / Pitch_{YAG}

- 350μm / 29μm/px = 25 px

➔ 8.3% Resolution



$\sigma_\delta = 2R\delta = 2(0.35m)(5x10^{-4}) = 350\mu m$

LEReC ERL schematic layout

Outside Issues: location of the 5 cell cavity and egun.

Beam line distance or distance as the crow flies?

Tolerance for the 5 cell location?